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Study on People Square's Mass Passenger Flow Management System Launched in Shanghai Urban Rail Transit

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Abstract

In order to deal with the mass passenger flow influenced backlog which is caused by casual emergencies that emerged in the station of People Sqaure in Shanghai urban rail transit system, the People Square's Mass Passenger Flow Management System (MPFMS) is studied and developed. In this paper, the overall function principle, the whole general framework and the main functional modules for this operation-assisted system are the three main constitutions that meticulously introduced. In short, the working procedure of the system can summarized as following: the days for passenger flow backlog are clarified as workday, weekend, long holidays. Then the passenger flow for arrival and departure the station, the transfer volumes among the different lines and in the same lines are accurately calculated and well analyzed. Finally, the simulations under various prerequisites are undertaken among the lines (line1, lin2, line8) involved in the People Square station. The proposal generated via this system is well matched with the dispatchers' operation scheme, proving the reliability and efficiency of this system.

Keywords: People Square, Mass Passenger Flow Management System (MPFMS); simulation and analysis; operation scheme;

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1. Introduction

Shanghai rail transit system is at the stage of its ever-growing development, with more and more operation lines and accelerating network scale. Under such premise, the Shanghai Metro is launching a rail transit network that "smothering the urban areas, spreading to the suburban new towns and connecting the main transportation hubs". Up to Jan. 2012, 11 lines, 287 stations, 420 railway running mileage are in operation for Shanghai Metro, the overall arrangement for this subway system is forming a net that rich in stations, multiple hubs, intensive equipment and systematic operation. Simultaneously, the rise of the passenger flow presents a kind of network effect, to be exact, the increment speed of the passenger flow is far surpass that of the transport capacity.

Under such circumstance, the transfer hubs are playing a significant role in attracting passenger flow in the given lines, however, the difficulty in construction, daily operation and emergency evacuation for the transfer hubs revealed that much need to be done in order to match with the role the transfer hubs plays. So, in case of the unforeseeable emergency, an accurate, prompt, high efficiency scheme is required in order to prevent the deterioration of the emergencies that happens in daily operation.

The People Square railway station is located in People Square in Huangpu District, Shanghai. This station is the transfer hub for line1, line2 and line8, among it are people square, people mansion, Shanghai museum, Shanghai art gallery, Nanjing pedestrian mall and other office buildings, the daily passenger flow are huge on normal workdays, the passenger flow on holidays (May day, National day and etc.) will be more, the other cultural activities that hold here would deteriorate the crowd level. The occurrence of the train delay would be likely to bring about the mass passenger flow backlog and eventually cause the emergencies that threaten public safety. Based on the above fact, this paper studied the People Square mass passenger flow incident and launched the operation-assisted system in dealing with the backlog.

2. The overall design for the MPFMS

2.1. The operation flow of the MPFMS

The dispatcher would ask the train driver to jump off the station under the prerequisite of the long-time train delay, in order to keep the amount of passengers in station under control so that the transfer hubs don't need to bear the brunt of transfer passengers at the critical time. The MPFMS we developed is aimed at the assisting the dispatcher in making jump off plans. The main workflow of the MPFMS that launched in Shanghai People Square station is shown in Fig1.

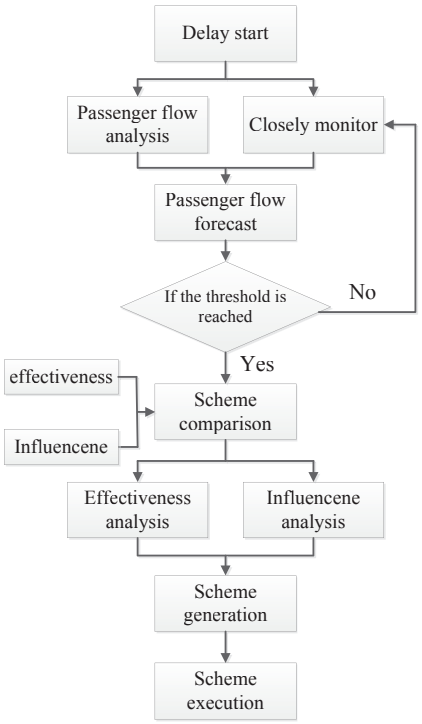

Fig. 1. the flow chart of the MPFMS

The operation scenario for this system can be present as follow. Once the delay of the train occurs, the dispatcher would on one hand keep a close surveillance on the changes of passenger flow at the station platform, on the other, use the MPFMS to analyze and forecast the characteristics of the passenger flow, the analysis and forecast is undertaken using the data from history with same date scenario and revised with a correction factor. At the moment the passenger density on the platform reached the threshold, the MPFMS will begin the process of scheme comparison, revealing the impact for Skip one special train. Based on the chart revealing validity and impact generated by the MPFMS, the dispatcher would choose which lines and how many times the trains on the chosen lines need to be jumped. When all the chosen is finished, the effectiveness and influence of the overall scheme is calculated by the MPFMS to see whether the choice satisfied the previously-set requirement, if so, the MPFMS would launch the Skip-Stop Scheme.

2.2. The operation flow of the MPFMS

The MPFMS system that we develop is a daily operation-assisting system. To satisfy the demand of the daily operators and to meet the need of data exchanging and sharing, the MPFMS adopts the C/S model. The Oracle data-base is adopted in consideration of the safety of the data, the capacity and the extendibility[3]. Three servers are put into daily operation in the MPFMS, one for the storage and management of the basic data, one for the data interchange with the thermal process, known as Interface server, the last one for the operation of the application known as Application server. Besides, multiple clients are required to fully-accomplish the function of the system. The overall physical structure for the MPFMS is shown in Fig 2.

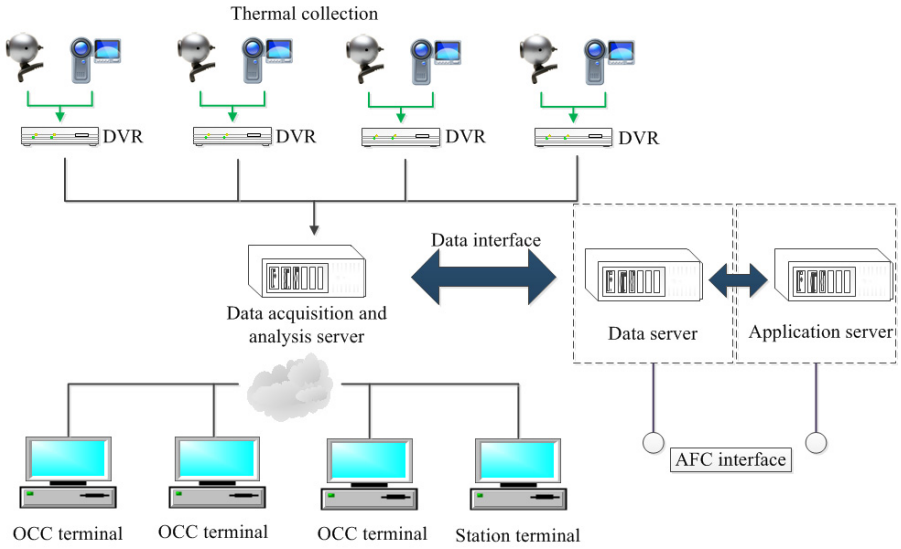

Fig. 2. the physical components of the MPFMS

2. The function design of the MPFMS

2.1. The overall functional structure of the MPFMS

The MPFMS is built among COCC, OCC and the People Square station, under the purpose of offering operation-assist to the dispatchers and station managers when the mass passenger flow backlog occurs. This system utilizes the gathered basic data and draw support from the urban rail transit operation organization, optimization method and computer technology. All the above technologies integrated in the MPFMS ensured its function in analysis of the passenger flow, passenger flow forecasting, the constitution and management of the operation adjustment (skip-stop) scheme under delay condition. The detailed functions are shown below:

- Passenger Flow calculation

The function of passenger flow calculation is performed using the basic data - original OD data, revenue clearing path-from the ticketing center. By utilizing the software Conet (a software to calculate the passenger flow distribution in the rail system), the volume of passengers for arrival and departure the station, the volume of transfer passengers under some given days can be calculated.

- Passenger Flow analysis

For the passenger flow data calculated for the given day by the software Conet, this module modifies them with a given correction factor and reveals them by using graphical techniques. This user-friendly interface provides an easy way for the dispatchers and managers to readjustment the operation scheme under the mass passenger flow backlog circumstance. The main numerical statistics and exhibition content is shown below.

The main function of the passenger flow analysis module is to analyze the passenger flow on the classified days. The volume of passenger that arrival and departure the station, the volume of passenger that transfer in and between the lines are calculated. The interface of this module is shown in Fig 3.

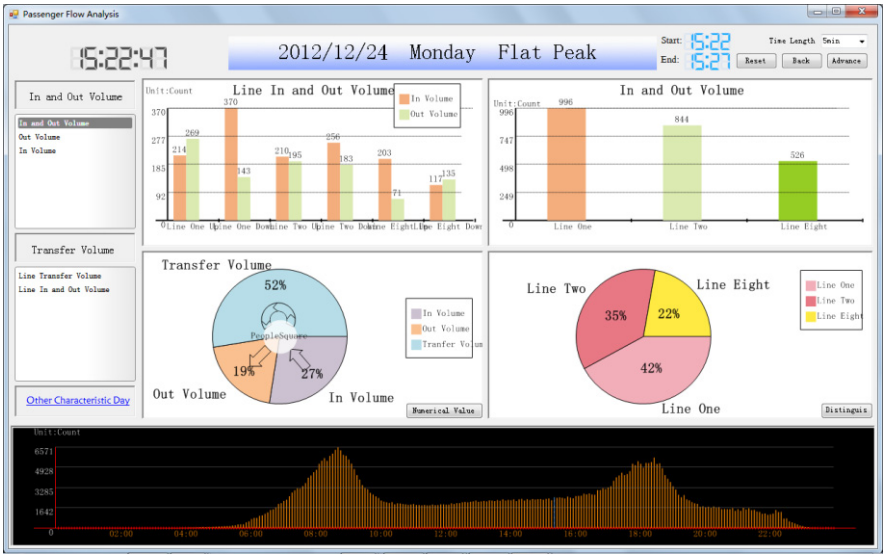

Fig. 3. Passenger flow analysis module for MPFMS

The analysis module is to forecast the rising tendency of the passenger volume on the platform, to analyze the influence and effectiveness of the chosen readjustment operation scheme, and to compare and select the proper readjustment operation scheme under the train delay condition. With this three main function, the role of helping dispatchers in making proper decision is well accomplished. This module is shown in Fig 4.

Fig. 4. Passenger flow disposal module

- The disposal of the huge passenger flow

This module simulates the changes of passenger volume on the platform and establishes the readjustment operation (skip-stop) scheme under the delay condition among morning peak (07:00a.m.-09:00a.m.)and night peak(17:00 p.m.-19:00p.m.), offering effective decision making basis to the dispatchers when real mass passenger flow backlog occurs.

(1)The delay condition can be imported intelligently, the user needs only to import the delay duration and line that delay occurs.

(2)The module can analyse and forecast the passenger flow on the platform and provide the threshold for readjustment operation scheme under various circumstances. The circumstances factor that might eventually affect the threshold is delay lines, delay duration, the passenger saturation on the platform.

(3)This module provides the decision makers with two vital data, one is "the impact on transfer passenger flow from and to the delayed line when one train is jumped" and the other is "the impact on the arrival and departure passenger flow from the station when one train is jumped". What's more, the frequency of jump is restricted when the delay duration is given.

(4)This module can analyse the scheme chosen by the decision-makers and shows the validity and influence of the chosen scheme and demonstrates it via graphical techniques.

(5)This module can generate the readjustment operation scheme and the corresponding passenger organization plan.

- Scheme simulation

The disposal of the huge passenger flow module is limited to the morning and night peak, this scheme simulation module performs the same function but with no time limits, the main purpose of this module is for drilling and daily practice.

- Scheme management

In order to help the users inquire and manage the readjustment operation scheme, this module is added to the MPFMS.

(1)The function of adding and deleting scheme is added.

(2)The function of modifying the module is added, the dispatchers can modify the scheme stored in the database via practical experience.

(3)The function of output report is added.

(4)The function of the Skip-Stop log management is added.

(5)The function of modify the password is added.

(6)The function of browse, add and delete operation organization scheme is added.

- Thermal analysis

This module is a reserved interface for the thermal system served for the ticket center.

The main function modules for the MPFMS are shown in Fig 5.

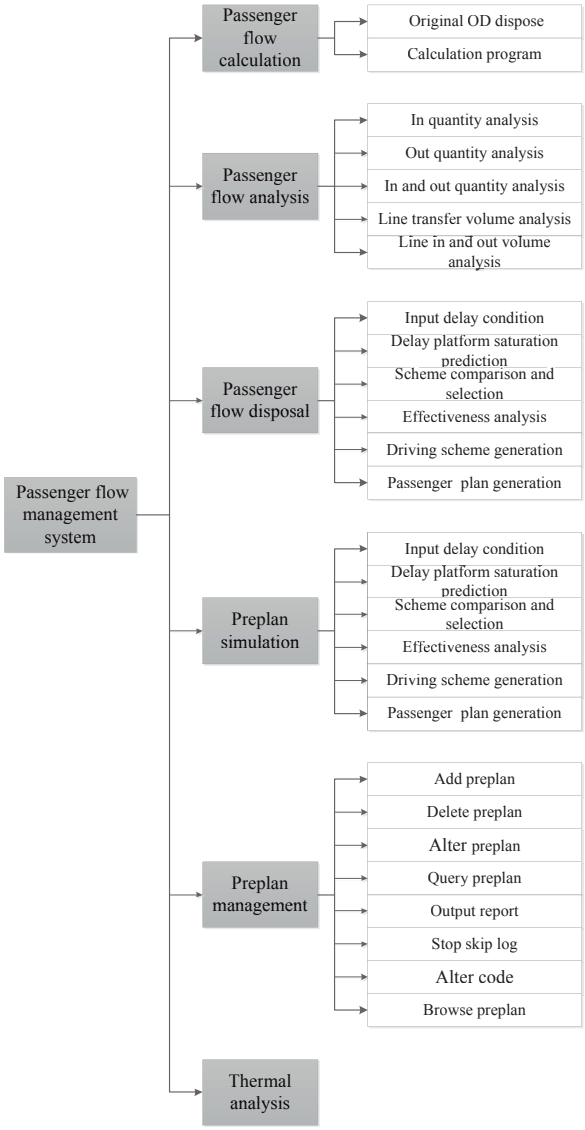

Fig. 5. Module and function for MPFMS

3. The example analysis

An executable and professional train operation adjustment (Skip-Stop) scheme with accuracy is needed in help the dispatchers dealing with the train delay accident and preventing the mass passenger flow backlog from happening. According to the regulation released by the government and the Metro system (The Regulations in dealing with the Mass Passenger Flow Backlog Accident), the train operation adjustment is needed when the platform passenger saturation level is above 80%. The basic principle on choosing the readjustment scheme is that the effectiveness is guaranteed and the negative impact should be kept as low as possible.

The examples in this paper are originated from the actual cases occurred in the People Square Railway Station, the readjustment schemes are calculated and analyzed by the MPFMS.

3.1. Case 1

- The essential information of the case

Table 1. The essential information for the signal fault accident occurs in Line 2

Date	July 3th,2012
Line No	Line 2
Reason for the accident	Songhong road signal failure
Duration of the accident	17：58—18：18
Duration to the People Square Station	Line down maximum delay 20min
Duration for the passenger-flow-limiting in People Square	18：19-18：39

- Method and procedure of the disposal
  (1)Passenger flow prediction

Fig .6. The prediction of the passenger volume under the condition of 20 min train-delay for the line 2 down train direction

As can be seen in the Figure 6 degenerated by the MPFMS, during the 20 min train-delay, the max passenger saturation level on the platform is about 65%, which is under the threshold of 80% (the triggering line for readjustment operation scheme), therefore, the dispatchers need only pay close attention to the platform but don't need to do any readjustment in train operation.

3.2. Case 2

- The essential information of the case

Table 2. The essential information for the ponding accident occurs in Line 1

date	August 8th ,2012
Line No	Line 1
Reason for the accident	Gongfuxincun-Hulan Road interval water
Duration of the accident	7：55—8：25
Duration to the People Square Station	Line down maximum delay 30min
Duration for the passenger-flow-limiting in People Square	8：25-8：55

- Method and procedure of the disposal
  (1)Passenger flow prediction

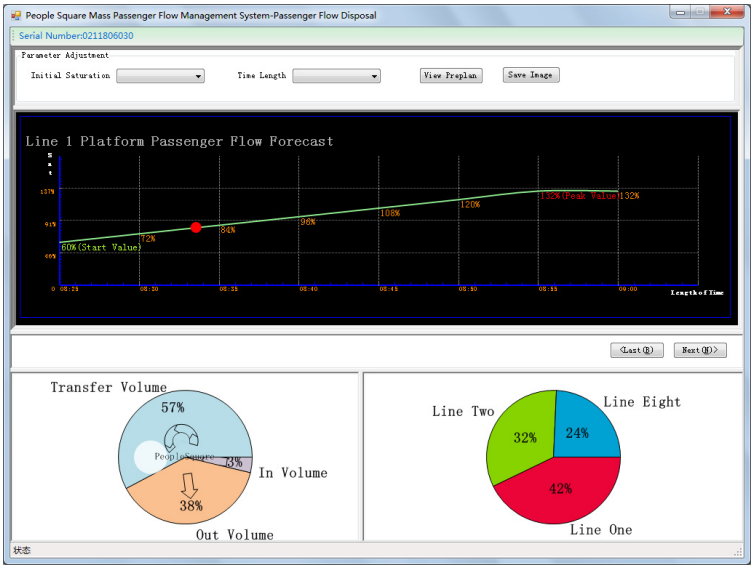

Fig.7. The prediction of the passenger volume under the condition of 30 min train-delay for the line 1 down train direction

In the chart above, we could see that during the 30 min train-delay, the max passenger saturation level on the platform is about 132%, which is above the threshold of 80%, therefore, the readjustment operation scheme need to be adopted immediately.

- The analysis of effectiveness and influence

Fig 8. Line 1 train delay under the condition of validity and effect analysis

From the analysis chart degenerated by the MPFMS, when the train delay accident occurs for the down train in Line 1, the most effective choice is to skip the up train from the Line 8, for 310 transfer passengers would postpone their time on arriving the People Square, thus, lower the possibility for the mass passenger flow backlog accident. While in comparison, the skip of the down train from the Line 2 brings about the least influence on the transfer passenger volume and departure passenger volume. Based on the effectiveness, influence and the running interval for different lines, the MPFMS generated the following readjustment scheme: four trains from the up train direction Line 8 should be jumped, four trains from the down train direction Line 2 should be jumped and the Level 2 mass passenger flow scheme is commenced.

- The comparison of the readjustment operation scheme

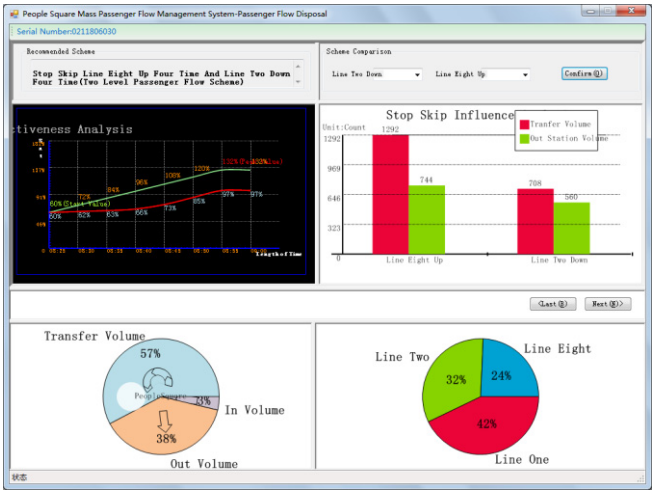

Fig. 9. Line 1 train delay conditions take scheme after the validity and effect analysis

Based on the influence of the readjustment operation generated by the MPFMS, the dispatchers would choose the skip lines and the skip trains. After analyzing the chosen skip train combination, the passenger density on the down direction platform is dropped from 132% to 97%, the influenced transfer and departure passenger volume on the up direction Line 8 and down direction Line 2 are shown in the table 3.

Table3. Take a skip-stop scheme on passenger flow and outbound passenger flow effect

	Line 8 Down	Line 2 Up
Transfer passenger flow	1292 People	708 People
Outbound passengers	744 People	560 People

3.3. Case 3

- The essential information of the case

Table4. The essential information for the train fault accident occurs in Line 8

date	August 20th ,2012
Line No	Line 8
Reason for the accident	Jiangpu road train fault
Duration of the accident	18：20—18：45
Duration to the People Square Station	Line up maximum delay 25min
Duration for the passenger-flow-limiting in People Square	18：44-19：09

- Method and procedure of the disposal

(1)Passenger flow prediction

Fig.10. The prediction of the passenger volume under the condition of 25 min train-delay for the line 8 down train direction

As can be seen in the chart degenerated by the MPFMS, during the 25 min train-delay, the max passenger saturation level on the platform of up direction Line 8 is about 87%, which is above the threshold of 80%- the base line for readjustment operation scheme, therefore, the readjustment operation scheme need to be adopted immediately.

(2)The analysis of effectiveness and influence

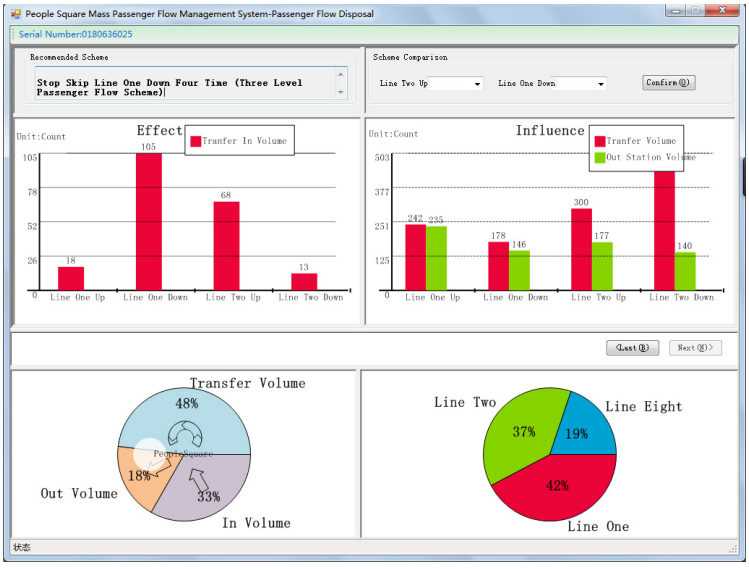

Fig. 11. Line 8 train delay under the condition of validity and effect analysis

Based on the influence of the readjustment operation generated by the MPFMS, when the train delay accident occurs for the down train in Line 8, it is the best choice to skip the down train from Line 1, as 105 transfer passengers would be postponed to arrival the platform, at the same time, the Skip of the down train from Line 1 influenced the less transfer passengers and departure passengers when compared with other readjustment. Based on the effectiveness, influence and the running interval for different lines, the MPFMS generated the following readjustment scheme: four trains from the down train direction Line 1 should be skipped and the Level 3 mass passenger flow scheme is commenced.

(3)The comparison of the readjustment operation scheme

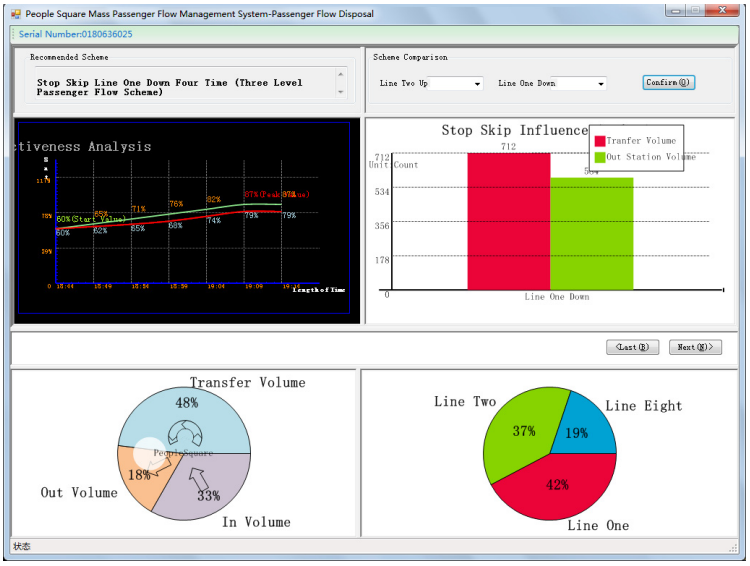

Fig. 11. Line 8 train delay conditions take scheme after the validity and effect analysis

Based on the influence of the readjustment operation generated by the MPFMS, the dispatchers would choose the lines and trains that can be jumped. After analyzing the chosen jump trains, the passenger density on the down direction platform is dropped from 87% to 79%, the influenced transfer and departure passenger volume on the down direction Line 1 are shown in the table 5.

Table5. Take a skip-stop scheme on passenger flow and outbound passenger flow effect

	Line 1 up
Transfer passenger flow	712 People
Outbound passengers	584 People

4. CONCLUSION

After the daily operation in People Square, it is proved that the MPFMS is practical in preventing the mass passenger flow backlog accident from happening, thus the risk of stampede and passenger casualty because of the excessive passenger flow is minimized. By utilizing the MPFMS, the dispatchers can have a clear anticipation on

the changes of the passenger density on the platforms and make an accurate and scientific reflect to the multivariate circumstance under the condition of train delay.

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